

# LRIO – Université Laval

## Equipment list and details

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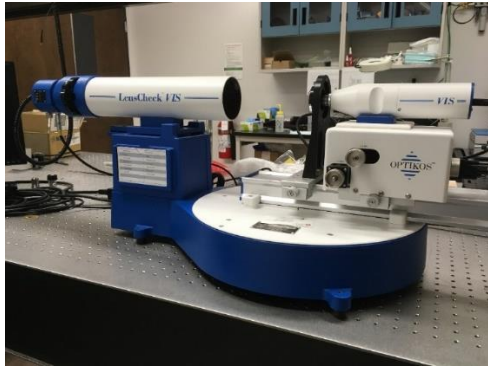
## Equipment list

Description	Manufacturer	Model
Optical test bench	Optikos	LensCheck VIS
Optical test bench	Trioptics	OptiSpheric
		OptiSurf
		OptiCentric
Point source microscope	Optical Perspectives Group	
Interferometer	Zygo	Mark GPI-XPS
Interferometer	Zygo	Verifire HD
Interferometer	ESDI	Intellium H2000
Stylus contact profilometer	Veeco	Dektak 150
Inspection microscope	Olympus	STM6
SEM/FBI microscope	FEI	Quanta 3D FEG
Scanning probe microscope	Veeco	Dimensions V
Thin coating system	Leybold	SYRUS-PRO-710
Thin coating system	Intlvac	Nanochrome
Prism coupler	Meticon	2010/M
Spectrometer	Agilent Technologies	Cary 5000 Vis-Nir
Spectrometer	Stellarnet	GW-VIS
Spectrometer	Ocean Optics	Flame-S-XR1-ES
Wavefront sensor (Shack-Hartmann)	Imagine Optics	HASO HR44
Wavefront sensor	Optocraft	n/a
Wavefront sensor (Shack-Hartmann)	Thorlabs	WFS30-7AR
Deformable mirror	ALPAO	DM97-15
Deformable mirror	IRIS AO	PTT111
Ultra precision machining system	Precitech	Nanoform 250
Surface profiler	Taylor Hobson	Talysurf PGI Freeform
Ultra precision polishing system	Zeeko	IRP200

## Equipment details

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### Optical test bench – Optikos LensCheck VIS



Measurement of MTF (on/off axis), EFL, F/#, BFL, astigmatism, field curvature and distortion.

MTF measurement accuracy: 2%

MTF measurement repeatability: 1%

Motorized lens platform: +/- 100 degree off-axis rotation

0.0001° resolution glass scale encoder

### Optical test bench - Trioptics



### *Trioptics OptiSpheric*

Measurement of standard lens and IOL parameters, EFL, BFL, FFL, radius, centering, MTF and diopter power.

- ✓ EFL resolution: 0.03 to 0.2%
- ✓ EFL Measurement accuracy:
- ✓ 5 to 25 mm: 0.1% to 0.3%,
- ✓ 25 to 500 mm: 0.03% to 0.1%
- ✓ 500 to 1000 mm: 0.05% to 0.3%
- ✓ MTF measurement repeatability: 1%
- ✓ MTF measurement accuracy: 2%
- ✓ BFL, FFL, and radius of curvature repeatability: 0.02 to 0.2%
- ✓ BFL, FFL, and radius of curvature accuracy: 0.03 to 0.3%

### *Trioptics OptiSurf*

Non-contact thickness and distance measurement within lenses and optical systems.

- ✓ Measurement accuracy: 1  $\mu\text{m}$  over measuring range
- ✓ Scanning range: 800 mm optical distance
- ✓ OptiSurf Professional software

### *Trioptics OptiCentric*

Centering error measurement, assembling, automated cementing and bonding of lenses, optics and optical assemblies.

- ✓ Centering accuracy:  $< 0.1$  arcmin (tilt),  $< 2$   $\mu\text{m}$  (decenter)
- ✓ Machining tolerances:  $< 2$   $\mu\text{m}$
- ✓ Flatness of plano surfaces:  $< 1$   $\mu\text{m}$
- ✓ Cylindricity of lens cell:  $< 1$   $\mu\text{m}$ .

## Point source microscope – Optical Perspectives Group



The Point Source Microscope (PSM) is used for optical system alignment. The instrument can perfectly align each optical component's center-of-curvature and position on its on-axis focused beam, exactly to specifications.

The PSM is also used for aligning aspheric optics, including off-axis aspheres. The PSM locates point images and shows the image shape as a star test. The PSM enables adjusting the asphere to reduce alignment error to near zero by keeping the image in the correct location while adjusting the asphere to minimize aberrations.

- ✓ Lateral sensitivity:  $\pm 0.5$  mm range,  $0.1 \mu\text{m}$  sensitivity with 10X objective
- ✓ Axial sensitivity:  $\pm 2 \mu\text{m}$  with 10X objective
- ✓ Angular sensitivity:  $\pm 1.4^\circ$  range,  $\pm 1$  arcsecond sensitivity when used as an autocollimator (no objective)

## Interferometer – Zygo Mark GPI-XPS



Phase-shifting interferometer with digital camera providing  $640 \times 480$  image acquisition.

4 inches test beam

1X to 6X zoom

Uses industry-standard 100 mm bayonet reference optics

ZYGO MetroPro 8.3.5 software running under Microsoft® Windows XP Professional

## Interferometer Zygo Verifire HD



Fizeau interferometer with digital camera providing 2304 X 2304 pixels.

4 inches beam

Uses industry-standard 100 mm bayonet reference optics

ZYGO MX software

## Interferometer - ESDI Intellium H2000



$\lambda/100$  P-V measurement error with no vibration isolation

Common-path Fizeau interferometry

4 inches test beam

Measurement speed as fast as 10  $\mu$ s

Measure surfaces with 0.1% to 100% reflectivity

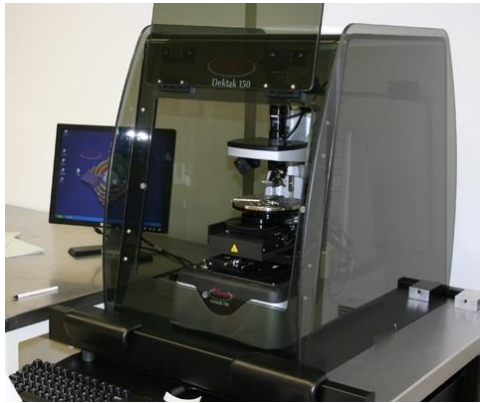
1X to 6X zoom

Uses industry-standard 100 mm bayonet reference optics

Total vibration insensitivity

ESDI IntelliWave software

## Stylus contact profilometer - Dektak 150



Advanced thin and thick film step height measurement tool.

Can be used to profile surface topography and waviness, as well as roughness at the nanometer scale.

- ✓ Step measurement: < 1 nm
- ✓ Sample diameter: up to 200 mm and up to 90 mm thick
- ✓ Repeatability: 0.6 nm

## Inspection microscope – Olympus STM6



UIS2 Optical System (Infinity-corrected)

Manual focus (2-axis/3-axis type)

Stroke: 155 mm

Coarse focusing speed: 4.8 mm/sec

Fine focusing speed (variable): 800  $\mu\text{m}$ /400  $\mu\text{m}$ /200  $\mu\text{m}$ /50  $\mu\text{m}$  (full rotation of knob)

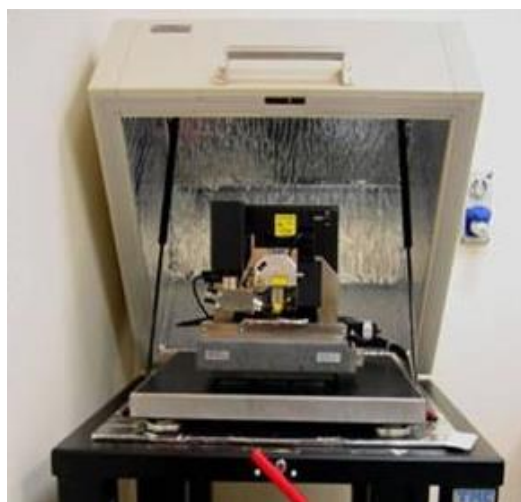


## SEM/FIB microscope FEI model Quanta 3D FEG



Scanning electron (SEM) and focused ion beam (FIB) microscope. The Quanta 3D FEG is the most versatile high-resolution, low vacuum SEM/FIB for 2D and 3D material characterization and analysis in the nanometer range. The FIB module can also be used to mill non-conductive samples in order to characterise the cross-section of a multilayer sample.

## Veeco Dimension V Scanning Probe Microscope



Atomic Force Microscopy (AFM) provides the ability to image the surface topography of both conducting and insulating samples, as well as adsorbed molecules and nanoparticles.

## Leybold SYRUS-PRO-710 Advance Plasma System (APS)



Plasma ion assisted deposition

Materials: Ti<sub>3</sub>O<sub>5</sub>, TiO<sub>2</sub>, SiO<sub>2</sub>, HfO<sub>2</sub>, Ta<sub>2</sub>O<sub>5</sub>, Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>, SnO<sub>2</sub>, ITO, MgOTi<sub>3</sub>O<sub>5</sub>, TiO<sub>2</sub>, SiO<sub>2</sub>, HfO<sub>2</sub>, Ta<sub>2</sub>O<sub>5</sub>, Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>, SnO<sub>2</sub>, ITO, MgO

Maximum substrate size: 4 inches in diameter

## Intlvac Nanochrome System



DC sputtering deposition

Materials: Si, Al, Nb, W, V, T, Ta

Maximum substrate size: 8 inches in diameter

## Thermal Evaporator (Homemade)



Materials: Al, Cu, Ag, Cr, Or

Maximum substrate size: 10 inch in diameter

## Electron Beam Physical Vapor Deposition or EBPVD



4 pockets of 7 cubic centimeter to evaporate 4 different materials

Materials: MgF<sub>2</sub>, ZnS, YF<sub>2</sub>, YbF<sub>3</sub>, SiO<sub>2</sub>

Maximum substrate size: 4 inch in diameter

These thin film deposition systems can produce anti-reflective, low-pass, bandpass coatings as well as Fabry-Pérot filters, metallic and dielectrics mirrors and transparent electrodes (ITO).

## Thin Films design software

TFcalc (<http://www.spectra.com/>)

MCalc Multilayer Calculation 4.0

## Metricon prism coupler mline model 2010/M



It uses optical waveguiding techniques to rapidly and accurately measure both the thickness and the refractive index/birefringence of dielectric and polymer films as well as refractive index of bulk materials. Operating at wavelengths 532, 633, 972, 1038 and 1538 nm.

- ✓ Index accuracy:  $\pm 0.0005$  (accuracy of up to  $\pm 0.0001$  available for many applications)
- ✓ Index resolution:  $\pm 0.0003$  (resolution of up to  $\pm 0.00005$  available for many applications)
- ✓ Thickness accuracy:  $\pm(0.5\% + 5 \text{ nm})$
- ✓ Thickness resolution:  $\pm 0.3\%$
- ✓ High accuracy index measurement of bulk, substrate, or liquid materials including birefringence/anisotropy
- ✓ Simple measurement of index vs wavelength
- ✓ Options to measure index vs temperature ( $dn/dT$ ), and waveguide loss
- ✓ Wide index measurement range (1.0-3.35)

## Spectrometer Agilent technologies model cary 5000 UV-VIS-NIR



The Cary 5000 is a high performance UV-Vis-NIR spectrophotometer with superb photometric performance in the 175-3300 nm range. It measures beyond 8.0 absorbance units with reference beam attenuation using Schwarzschild coupling optics for higher accuracy at low transmission levels ensuring Maximum light throughput.

## Spectrometer Stellarnet inc green-wave model GW-Vis



The SpectraWiz software is included to accurately measure wavelength emissions, reflectance, transmission, absorption, concentrations, and absolute intensities.

- ✓ Visible wavelength range (350-1150)
- ✓ With integrating sphere (IC-2)

## Spectrometer Ocean Optics FLAME-S-XR1-ES



These compact spectrometers integrate performance-enhancing features and are produced using industry-leading manufacturing techniques.

- ✓ Visible wavelength range (200-1025)
- ✓ With integrating sphere
- ✓ With calibration source

## Wavefront sensor Imagine Optics HASO HR44

HASO Shack-Hartmann type wavefront sensor with control software.

- ✓ 44 X 44 microlenses (150  $\mu\text{m}$  pitch)
- ✓ Aperture dimensions 5 X 5  $\text{mm}^2$
- ✓ Wavefront measurement accuracy in absolute mode RMS:  $\lambda/100$
- ✓ Wavefront measurement accuracy in relative mode RMS:  $\lambda/150$
- ✓ Maximum acquisition frequency: 77 Hz
- ✓ Waveband: 350-1100 nm

## Wavefront sensor Optocraft custom

Shack-Hartmann wavefront sensor based on a Photonfocus MV1-D1312-240-CL-8 camera (Camera Link) equipped with a 35 x 35 microlens array having a 150  $\mu\text{m}$  pixel pitch.

## Wavefront sensor Thorlabs WFS30-7AR



General purpose Shack-Hartmann for wavefront sensing with a 10 X 10 microlens grid with a pitch of 150  $\mu\text{m}$  and an aperture of 11.34 X 7.13 mm.

- ✓ Visible and NIR wavelength range (400-900 nm)
- ✓ Wavefront accuracy @ 633 nm of  $\lambda/40$  rms
- ✓ Wavefront sensitivity @ 633 nm of  $\lambda/120$  rms
- ✓ Frame rate 8-64 Hz

## Deformable mirror ALPAO DM97-15



ALPAO Deformable Mirrors are based on continuous reflective surface motioned by magnetic actuators. They feature large strokes, high dynamic motion and an excellent optical quality to meet and exceed your requirements for fast and accurate wavefront correction.

- ✓ 97 actuators with 0.8 mm pitch
- ✓ Pupil diameter: 13.5 mm
- ✓ Tip/tilt stroke: 60  $\mu\text{m}$  PV, wavefront
- ✓ Settling time: 0.8 ms at  $\pm 10\%$ , any stroke

## Deformable mirror IRIS AO DM PTT<sub>111</sub>



Deformable mirror and control system (2 units available).

- ✓ Number of actuators: 111
- ✓ Number of segments: 37
- ✓ Stroke: 7  $\mu\text{m}$
- ✓ Mirror diameter: 3.5 mm



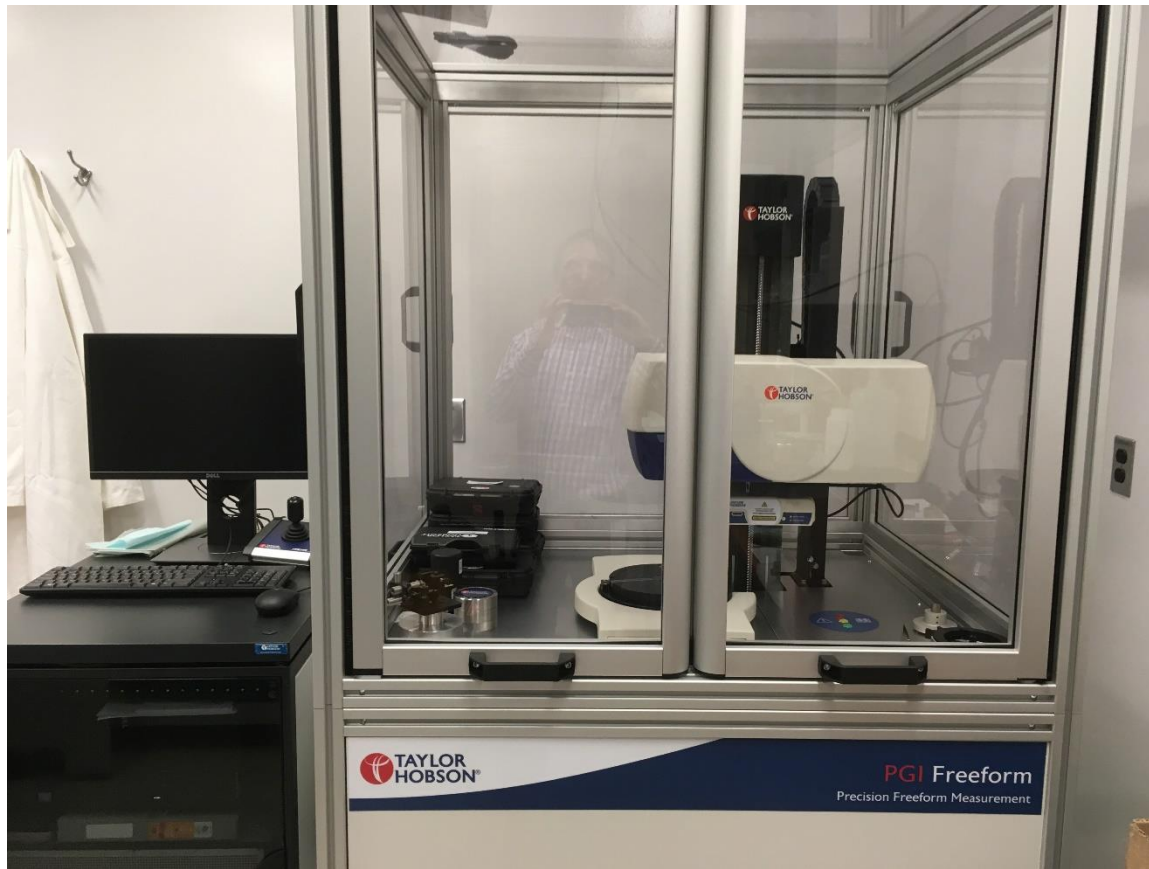
## Nanoform 250 Ultra Precision Machining System



This 4-axes (X, Z, C, B) diamond turning machine allows form accuracy of less than 0.15 microns PV and surface roughness under 1.5 nm Ra. It can also perform deterministic freeform milling and grinding to a form accuracy of less than 0.20 microns PV and surface roughness under 5 nm Ra. It has a 16-picometer feedback resolution and an operating system with 0.01 nanometer programming resolution and can accommodate optical parts of up to 8-inches diameter and various materials such as metal, glass, plastic and ceramic.

- ✓ Single Point Diamond Turning
- ✓ Tool Normal Diamond Turning
- ✓ High Speed Machining
- ✓ Raster/Groove Milling
- ✓ Fly-cutting
- ✓ Non-Rotationally Symmetric Freeform Machining
- ✓ Slow Tool Servo

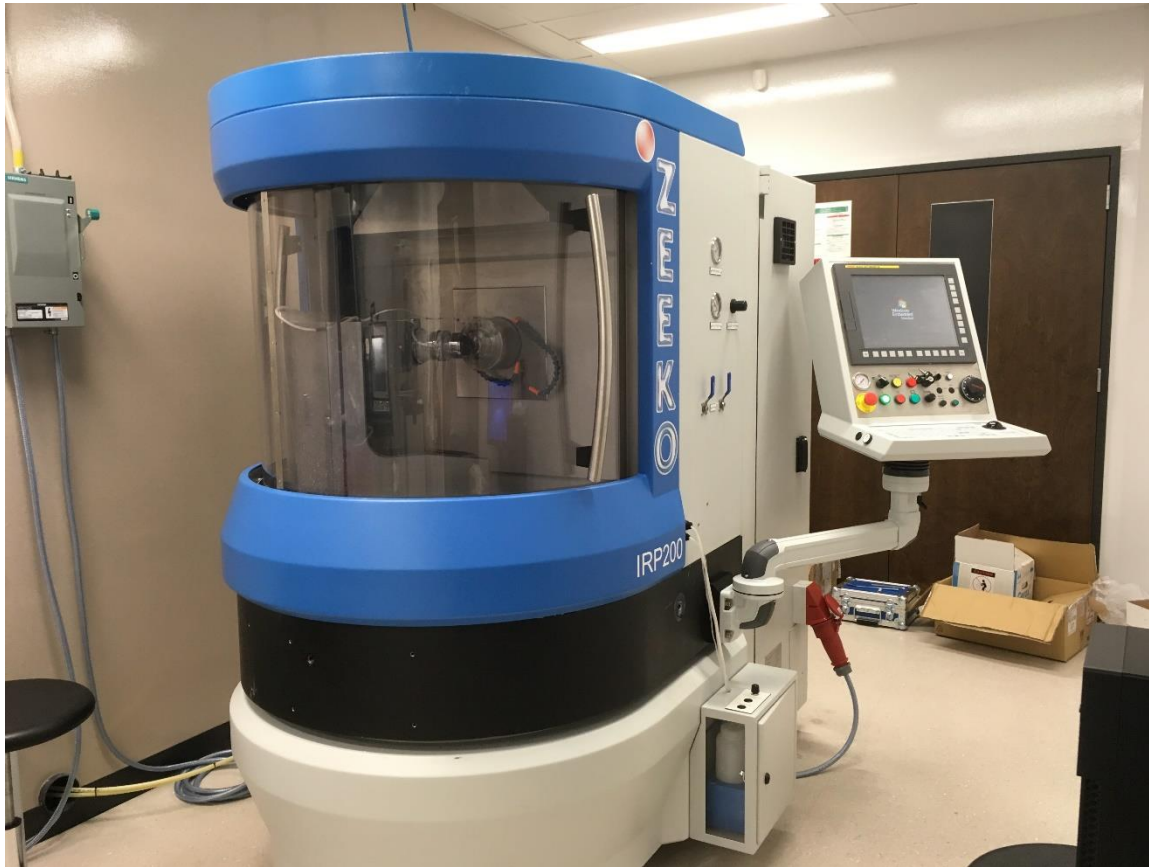
## Talysurf PGI Freeform Surface Profiler



The PGI Freeform is a dedicated metrology instrument for precision form measurement of 3D form of shallow and steep aspherical lenses and moulds from <2mm and up to 300mm diameter.

Form repeatability of <100 nm and slope angles of up to 85 degrees mean that the instrument is a versatile tool for spherical, aspheric, diffractive lenses and molds, which allows a wide range of accurate 2D and 3D measurements and analysis.

## Zeeko IRP200 Ultra-Precision Polishing Machine



The IRP 200 is a 7-axis CNC optical polishing machine capable of producing ultra-precise surfaces on a variety of optical materials and surface forms. The machine axes can be used for traditional spiral polishing or raster polishing within a total envelope size of 300x260x130. For parts up to 200mm in diameter or freeform parts up to 200mmx200mm.

- ✓ 7-axis CNC control with 3 linear and 4 rotational axes enabling automatic figure control
- ✓ Variable tool sizes: diameter 20, 40 and 80 mm
- ✓ Patented polishing head with variable polishing spot
- ✓ Automatic moderation functionality for pre-polishing process
- ✓ CAD lens design data imports with interfaces for various standard software packages
- ✓ Upgradeable Precessions<sup>TM</sup> optimization software (2D, 2.5D, 3D) ·
- ✓ Metrology data import (e.g. Veeco / Wyko, Zygo, FISBA, ADE, ZEISS, Panasonic and Taylor Hobson)

## Scientific cameras and detectors

Type	Manufacturer	Model	Quantity
CMOS camera	1st vision	IDS-U3-3060CP2-M	3
CMOS camera	Allied Vision Technologies	Guppy – GF 503C IRF	2
CMOS camera	Allied Vision Technologies	Guppy – GF 503 C	1
IP camera	IQ eye	511	1
Webcam	Logitech	V-U0027	1
CMOS camera	Lumenera	LW570C	1
CMOS camera	Lumenera	LM075M	1
Webcam	Microsoft	Lifecam – VX-3000	1
Webcam	Microsoft	Lifecam cinema 1393	1
	PhiHong power supply and connector	PSA16U-480	1
Camera	Photon focus	-	1
CMOS camera	Point Grey	Grasshopper 3 – GS3-U3-41C6M	1
Camera	Point Grey	Dragonfly 2 – DR2-0852M-EX	2
Camera	SBIG	05 103979	1
Camera	Teledyne Dalsa	Genie – G2-GM10-T2561	1
CCD camera	Thorlabs	DCU-223M	1
Photodiode	Thorlabs	DET10A	1
Photodiode	Thorlabs	PDA10A	1
Photodiode	Thorlabs	PDA36A	1

## Imaging systems and objectives

Manufacturer	Model	Quantity
Asahi	150mm F4 M42-Mount	1
Asahi	50mm F4 C-Mount	1
Azure	5 MP	1
Cosmicar	50mm F1.8 C-mount	1
Cosmicar	12.5-75mm F1.8	1
Cosmicar	16mm F1.4 C-Mount	1
Edmund optics	8mm F12x0.5 (69-295)	1
Edmund optics	8.5mm F1.3 (58-000)	1
Edmund optics	20x NA 0.40	1
Edmund optics	25mm F2.5 (58-207)	1
Edmund optics	25mm F1.4 (59-871)	1
Edmund optics	35 mm F1.65 (85-362)	1
Fujinon	12mm F1.4 C-Mount (HF12-55A-1)	1
Fujinon	8mm F1.8 C-mount (HF818-12M)	1
Immervision	IMV1 - 1/3 CS-Mount	3
Immervision	IMUI-Y3 CS-Mount	1
Immervision	IMV1-1/3-NI	4
Immervision	RPL-A8PRT	1
Kowa	8.5mm F1.8 C-Mount	1
Kowa	12mm F1.9 C-Mount	1
Mamiya	45mm F2.8 64S-Mount	1
MellesGriot	40x NA0.65	1
MellesGriot	4X beam expander	1
Navitar		1
Newport	5x NA0.10	1
Newport	10x NA0.25	4
Newport	20x NA 0.40	2
Newport	20x NA0.41	1
Olympus	10X NA0.25 (FN22 VIS2)	1
Pentax	28-80mm F3.5-5.6 K-Mount	1
Ricoh	5mm F1:1.8	1
Sunex	0.97 mm Fisheye (DSL180A-NIR-F2)	1
VS Technology Coroporation	VS-1214H1	1
-	10x NA0.25	1
-	5x NA0.12	1
-	20x NA 0.40	1
-	20x NA 0.40	1
-	12mm F1.8 C-Mount	1
-	75mm F1.3	1

## Light sources and lasers

Manufacturer	Model	Description	Wavelength/ color	Power	Quantity
<b>LASERS</b>					
Thorlabs	S3FC520	Fabry-Perot benchtop laser	540 nm	4 mW	1
Newport	3225H-PC	HeNe laser	632.8 nm	~10 mW	1
REO	LSTP-1010	Multi-line HeNe laser	633, 612, 604, 594, 543 nm	4 mW (@ 633 nm)	1
Thorlabs	HNL020L	HeNe laser, polarized	632.8 nm	2 mW	1
Thorlabs	HRR005-1	HeNe laser	633 nm	0.5 mW	1
Thorlabs	HLS635	FC/PC handheld laser	635 nm	1 mW, 2.5mW, pulsed	1
-	-	HeNe laser	633 nm	<1 mW	1
Thorlabs	LP642-SF20	Pigtailed laser diode	642 nm	20 mW	1
Thorlabs	LPS-PM785-FC	Pigtailed laser diode	785 nm	6.25 mW	1
Thorlabs	LP852-SF30	Pigtailed laser diode	852 nm	30 mW	2
<b>WHITE SOURCES</b>					
Dolan-Jenner	Fiber Lite 190	Fiber optic Illuminator	3100 K	30 W	1
Gagné inc	Porta-trace	Neon square	-	-	1
Thorlabs	OSL1	Fiber illuminator	3200 K	1.4 W	1
Thorlabs	SLS201	Stabilized Tungsten Halogen Light Source	-	9W	1
-	-	Neon lamp	-	-	1
<b>LEDs</b>					
Nichia	NCSW119JE	LED	White	346 lm	20
Pimoroni	Unicorn HAT HD pim 273	LED matrix	RGB	-	1
Thorlabs	LIU002	LED array	Green	111 mW	1
Thorlabs	M660F1	Fiber-coupled LED	660 nm	13 mW	1
-	LED-5001	Video camera light	White	-	1

## Laser safety glasses

Manufacturer	Wavelength (nm)	OD
Trinity Technologies	630-650	2
	650-690	3
	690-1330	6
	10 600	5
Trinity Technologies	630-650	2
	650-690	3
	690-1330	6
	10 600	5
LaserShields	190-380	5
	630-700	1.5
LaserShields	180-400	5
	720-770	4
	730-767	5
	960-1067	4
	990-1040	5
LaserShields	190-400	5
	525-532	1.5
	633-655	1.4
Sperian	625-680	1